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PROPERTIES OF 50 INDIVIDUAL PHILIPPINE HARDWOOD BARKS AND MIXTURES OF 22 GHANAIAN AND 18 COLOMBIAN HARDWOOD BARKS

By

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UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
In Cooperation with the University of Wisconsin

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Summary

Bark specific gravity tends to be higher than the wood specific gravity for the 50 Philippine hardwoods evaluated. This trend, however, is reversed in the case of those species having a wood specific gravity of 0.70 and greater. Silica and ash contents of the barks were much higher than those found in the woods. Kraft pulp yields from bark were somewhat less than those found for barks from Temperate Zone species. Heat value was very similar to those found in barks of native U.S. species.

Introduction

The tropical hardwood forests of the world comprise a very large but undeveloped natural resource. In addition, most of these forests are located in developing countries. If these forests could be more completely and efficiently utilized, under sound conservation practices, they could make a great contribution to the economic growth of the tropical countries.

1/ Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

The tropical hardwood forests are made up of a large number of species growing in mixture, and only a relatively few preferred species find a ready world market. The removal of the preferred species leaves a large number of residual species to occupy the land. Such practices are destructive and wasteful of potentially valuable natural resources. The thousands of residual species represent a vast and underutilized resource in most of the developing countries, particularly the forests of west Africa, southeast Asia, and South America.

The reasons for uneven utilization of the tropical forests appear to be as complex as the heterogeneous forests themselves. One of the obstacles of more complete utilization is the lack of knowledge of the physical and technological properties of the residual species. Increased knowledge of the properties could be beneficial in developing market outlets for such little-used or unused woods. There are, of course, other obstacles which have prevented utilization of the residual species. Lack of adequate transportation facilities, remoteness, inadequate marketing mechanisms, and other factors combine to inhibit efficient management and use of tropical forests.

To successfully utilize the mixture of species found in the heterogeneous tropical hardwood forests requires departure from the conventional species-by-species determination of wood properties. A more fruitful approach is the development of a nontaxonomic or nonspecific utilization system. Such a system is the "any tree-whole tree" approach suggested by Chudnoff (1969). Booth (1972) also proposed a species-tolerant system for pulp, hardboard, particleboard, charcoal, and fuel uses as a general

solution for the development of tropical and subtropical mixed broad-leaved forests. This approach was also supported in the Secretariat Note of Commission VII at the Seventh World Forestry Congress (Gonzalez, 1972), where, on the question of utilization of the tropical forests, it was stated that "the main goal should be the development of species-tolerant processes in which the identity of individual species is to a large degree lost."

The success of grouping tropical hardwood species to reflect the xylem pool found in specific life zones[2/] was recently reported by Chudnoff (1976). He found that mixtures of various species did form distinctive wood specific gravity patterns, at least in life zones that describe the lowland tropical forests; that is, mean annual precipitation over 1,000 millimeters and mean annual biotemperature above the frost or critical temperature line.

With the environmental constraints now being imposed, it is essential that maximum utilization be made of all above-ground portions of each harvested tree, including the bark. One purpose of this study is to describe certain physical and chemical characteristics of bark from 50 species sampled from the tropical forests of the Philippines. Enumeration of such data will allow evaluation of the utilization potential of the bark from mixtures of species found in the various life zones of the tropical forests in southeast Asia. Another purpose is to evaluate the utilization potential of bark mixtures made from tropical hardwoods grown in both Ghana and Colombia.

2/ For a more detailed explanation of the world life zone classification system, refer to a report by Holdridge et al. (1971).

Experimental

Bark samples were cut from the lower end of each of 90 butt logs representing 50 species found in the Philippine tropical forests. The chemical and physical characteristics evaluated on each bark sample and the method employed include:

(1) Bark specific gravity--dry weight, green volume basis.

(2) Wood-bark ratios--expressed as percent of the ovendry weight.

(3) Ash and silica contents.

(4) Extractives--percent of ovendry weight.

(A) Ether--extracted for 5 hours.

(B) Hot water--extracted with hot water for 15 hours.

(C) Alcohol benzene (1:2)--extracted for 6 hours.

Samples were extracted in the above listed order.

(5) Heat value--expressed as British thermal units (Btu) per pound of dry bark.

(6) Yield of kraft cooked bark samples.

The bark samples were hammermilled and then ovendried. A 200-gram sample of each species was weighed and placed in a cotton gauze bag for cooking. Three species of bark were cooked at the same time in a 0.8-cubic-foot digester also containing 6 pounds of red oak chips. The cooking liquor of 25 percent sulfidity was mixed to contain 18 percent active alkali based on the total dry weight of bark and oak chips. Cooking time was 90 minutes from 80° to 170° C. and 90 minutes at 170° C. The cook was blown down and washed in the digester with hot water. Each bark sample was agitated in a blender at low speed for 1 minute in

approximately 1 gallon of hot water. The bark fibers were classified in a Bauer-McNett classifier which retained those fibers passing through a size 10 screen and held on a size 150 screen. All fibers passing through the size 150 screen were discarded. The retained fibers were dewatered using a Buchner funnel and then ovendried and weighed.

All of the barks peeled from both the Colombian and Ghanaian hardwood logs were ovendried and weighed to determine the individual wood-to-bark ratios. Mixtures of Colombian and Ghanaian barks were made by combining 200-gram samples of the individual dried barks. These mixtures were analyzed for ash and silica contents and heating values.

Results

The physical and chemical characteristics of bark evaluated for the 50 Philippine species are shown in tables 1 and 2.

Generally speaking, the bark specific gravity tends to increase with wood specific gravity. This trend, however, is reversed in the high wood density species. Looking at those species having wood specific gravity above 0.70, it is evident that the bark specific gravity is less than that found for the wood.

The ash content of the bark ranged from 1 to 36 percent and was always much greater than the ash content of the wood. Silica content was also much greater in the bark than the wood and ranged from a trace to over 34 percent. The highest bark ash and silica contents were found in those species having a wood specific gravity range from 0.52 to 0.69. It appears that high specific gravity bark will also have correspondingly high ash and silica contents.

The amount of bark extractives ranged from 2 to 24 percent and, for all practical purposes, was independent of the specific gravity for either the wood or bark.

The heat value expressed as Btu's per pound of ovendry bark ranged from 4,800 to 9,000, which is in the range of values found for our native U.S. species. While a clear-cut pattern was not evident, there does appear to be an association between bark specific gravity, heat value, and extractive content. A high extractive content, coupled with a high specific gravity, does result in a high bark heat value.

In terms of wood-bark ratios, the percent of wood, as measured in the butt log, ranged from 85 to 96 percent. This is somewhat higher than found in most of the coniferous species indigenous to the United States. This would indicate that the bark of the tropical species is thinner than bark of trees in the Temperate Zone.

The kraft pulp yields ranged from 7 to 34 percent, which appears to be less than what we find in bark pulps from Temperate Zone species. Additional work on the anatomy of the bark is required before a valid assessment can be made of the observed pulp yields.

The wood-to-bark ratios of the 18 Colombian and 22 Ghanaian hardwoods are given in table 3, while the ash, silica, and heat values of the bark mixtures are given in table 4.

This information on the physical and chemical properties of bark should aid in evaluating the utilization potential of the bark found in the tropical forests. Additional efforts are now needed to associate the bark properties found in the various life zones. Such evaluation is essential if we are to achieve maximum utilization of the wood and bark from the heterogeneous tropical forests.

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Table 1.--Wood and bark properties of 50 Philippine hardwoods

Species			Wood			Bark				
No.	Common name	Botanical name	Specific gravity[1]	Ash[2]	Silica[2]	Specific gravity[1]	Ratio Wood	Ratio Bark	Ash[2]	Silica[2]
				Pct	Pct		Pct	Pct	Pct	Pct
1	Tangisang-bayauak	Ficus variegata	0.24	3.64	0.02	0.46	91	9	12.39	1.21
2	Binuang	Octomeles sumatrana	.24	1.32	--	.33	89	11	3.84	.10
3	Kapok	Ceiba pentandra	.24	4.45	--	.38	86	14	5.23	.08
4	Balilang-uak	Melisoma macrophylla	.26	1.34	.04	.37	91	9	13.31	3.83
5	Rarang	Erythrina subumbrans	.26	1.61	--	--	92	8	19.15	.31
6	Kaitana	Zanthoxylum rhetsa	.30	.75	.01	.41	88	12	4.92	.11
7	Ilang-ilang	Cananga odorata	.31	1.46	.02	.43	87	13	7.43	1.70
8	Gubas	Endospermum peltatum	.32	.62	.01	.48	93	7	2.17	.17
9	Dita	Alstonia scholaris	.32	1.08	.01	.32	96	4	5.82	.32
10	Anabiong	Trema orientalis	.32	1.00	--	.50	90	10	7.34	.65
11	Hamindang	Macaranga bicolor	.32	1.46	.02	.49	--	--	11.51	4.06
12	Balanti	Homalanthus populneus	.36	1.17	.01	.58	88	12	9.99	.87
13	Mayapis	Shorea squamata	.37	.36	.04	.47	85	15	1.85	.15
14	Matang-arau	Melicope triphylla	.38	1.05	.43	.28	94	6	2.16	.23
15	Malasantol	Sandoricum vidalii	.39	.61	.01	.54	94	6	3.29	.11
16	White lauan	Pentacme contorta	.40	.72	.06	.43	90	10	6.20	.06
17	Tulo	Alphitonia philippinensis	.42	.47	.01	.49	--	--	7.33	.08
18	Tangile	Shorea polysperma	.43	.20	.08	.50	92	8	2.09	.04
19	Pahutan	Mangifera altissima	.44	2.91	.02	.62	85	15	23.32	16.95
20	Apanit	Mastixia philippinensis	.45	1.72	.10	.45	87	13	7.00	.01
21	Lago	Pygeum vulgare	.45	.50	.01	.59	89	11	3.78	.06
22	Antipolo	Artocarpus blancoi	.47	5.21	4.55	.36	90	10	16.13	11.35
23	Bagtikan	Parashorea plicata	.48	1.42	.01	.52	91	9	13.59	.14
24	Sakat	Terminalia nitens	.49	.68	.10	.44	93	7	19.65	.43
25	Red lauan	Shorea negrosensis	.51	.09	.03	.49	90	10	1.02	.05
26	Itangan	Weinmannia luzoniensis	.53	1.52	.01	.60	91	9	5.43	.33
27	Piling-liitan	Canarium luzonicum	.55	.73	.21	.62	--	--	20.19	15.30
28	Palosapis	Anisoptera thurifera	.55	1.17	.72	.66	85	15	6.90	6.13
29	Lomarau	Swintonia foxworthyi	.56	1.00	.10	.59	94	6	6.77	.24
30	Malabetis	Madhuca oblongifolia	.56	3.01	2.19	.52	--	--	25.70	24.23
31	Dangkalan	Calophyllum obliquinervium	.57	.65	.01	.44	87	13	4.77	.09
32	Panau	Dipterocarpus gracilis	.58	.93	.43	.82	88	12	35.91	34.63
33	Katmon	Dillenia philippinensis	.59	1.06	.02	.81	87	13	7.55	1.06
34	Batitinan	Lagerstroemia piriformis	.60	3.56	.01	.55	91	9	13.79	.22
35	Katong-lakihan	Amoora macrophylla	.61	.84	.03	.46	92	8	8.86	.11
36	Narig	Vatica mangachapoi	.62	.74	.22	.61	88	12	24.14	22.18
37	Miau	Dysoxylum euphlebium	.62	1.16	.04	.46	92	8	5.12	.61
38	Apitong	Dipterocarpus grandiflorus	.62	.69	.23	.72	93	7	22.96	21.69
39	Bok-bok	Xanthophyllum excelsum	.64	1.11	--	.64	--	--	6.05	.01
40	Kamatog	Erythrophloeum densiflorum	.65	1.62	.01	.63	91	9	16.86	10.14
41	Dalingdingan	Hopea foxworthyi	.67	.70	.04	.66	88	12	4.56	.10
42	Katilma	Diospyros nitida	.68	2.51	.02	.57	--	--	7.95	.15
43	Yakal	Shorea astylosa	.72	.92	.03	.54	89	11	7.77	.20
44	Kamagong	Diospyros philippinensis	.72	2.98	.01	.42	96	4	12.45	.25
45	Katong-matsin	Chisocheton pentandrus	.72	.78	.02	--	--	--	--	--
46	Manaring	Lithocarpus soleriana	.74	.79	.02	.67	89	11	4.45	1.31
47	Ipil-ipil	Leucaena leucocephala	.74	.91	.01	.43	91	9	7.68	.17
48	Bolong-eta	Diospyros pilosanthera	.74	1.96	.02	.61	91	9	8.38	.17
49	Makaasim	Syzygium nitidum	.78	.78	.03	.53	94	6	2.97	.09
50	Alupag-amo	Litchi philippinensis	.79	1.10	.01	.78	91	9	10.05	.52

1/ Dry weight, green volume basis.
2/ Based on moisture-free weight.

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Table 2.--Extractives content, heat value, and kraft pulp yield of bark from 50 Philippine hardwoods

Species			Bark characteristics				Kraft pulp yield[1/]	
			Extractives[1/]					
No.	Common name	Botanical name	Ether	Hot water	Alcohol benzene	Heat value[1/]	+10 mesh	10/150 mesh
			Pct	Pct	Pct	Btu/lb	Pct	Pct
1	Tangisang-bayauak	Ficus variegata	6.31	4.18	11.82	7,524	2.88	10.85
2	Binuang	Octomeles sumatrana	.63	5.79	6.92	8,172	3.94	27.12
3	Kapok	Ceiba pentandra	.46	4.84	5.34	7,686	5.98	31.20
4	Balilang-uak	Melisoma macrophylla	.76	6.36	7.34	7,056	.05	16.76
5	Rarang	Erythrina subumbrans	1.78	8.30	12.93	4,842	.01	12.24
6	Kaitana	Zanthoxylum rhetsa	.23	5.00	5.21	8,020	8.87	19.58
7	Ilang-ilang	Cananga odorata	.43	5.47	6.30	7,518	6.30	27.00
8	Gubas	Endospermum peltatum	.70	1.70	2.82	8,406	.04	19.19
9	Dita	Alstonia scholaris	4.57	5.10	11.66	8,712	.04	19.79
10	Anabiong	Trema orientalis	.19	3.13	3.36	7,920	12.38	7.28
11	Hamindang	Macaranga bicolor	.09	3.33	3.63	7,416	1.44	27.21
12	Balanti	Homalanthus populneus	.17	2.28	2.84	7,506	.02	10.17
13	Mayapis	Shorea squamata	.40	3.60	4.13	8,604	.17	28.57
14	Matang-arau	Melicope triphylla	2.01	5.00	8.86	8,766	.12	18.91
15	Malasantol	Sandoricum vidalii	10.60	3.57	16.53	9,000	.13	9.60
16	White lauan	Pentacme contorta	.64	5.87	8.16	7,938	.01	28.10
17	Tulo	Alphitonia philippinensis	2.47	3.64	7.49	7,722	.01	11.59
18	Tangile	Shorea polysperma	.47	2.85	3.66	8,316	0	32.22
19	Pahutan	Mangifera altissima	.63	6.68	8.13	6,246	.79	26.80
20	Apanit	Mastixia philippinensis	1.09	4.53	6.30	7,578	.75	27.64
21	Lago	Pygeum vulgare	.28	3.97	4.22	8,100	.02	27.26
22	Antipolo	Artocarpus blancoi	3.20	15.54	22.55	7,650	7.61	7.84
23	Bagtikan	Parashorea plicata	.46	2.97	4.58	6,948	.89	33.70
24	Sakat	Terminalia nitens	.31	20.92	24.36	5,364	2.24	26.74
25	Red lauan	Shorea negrosensis	.99	7.11	8.69	8,586	.38	33.94

(Sheet 1 of 2)

Table 2.--Extractives content, heat value, and kraft pulp yield of bark from 50 Philippine hardwoods--Con.

Species			Bark characteristics				Kraft pulp yield 1/	
			Extractives 1/					
No.	Common name	Botanical name	Ether	Hot water	Alcohol benzene	Heat value 1/	+10 mesh	10/150 mesh
			Pct	Pct	Pct	Btu/lb	Pct	Pct
26	Itangan	Weinmannia luzoniensis	0.32	4.05	5.45	7,938	0.79	23.94
27	Piling-liitan	Canarium luzonicum	.69	6.17	7.19	5,076	.18	17.68
28	Palosapis	Anisoptera thurifera	.31	2.53	3.77	8,028	.12	27.00
29	Lomarau	Swintonia foxworthyi	.29	2.53	3.90	7,866	.09	9.93
30	Malabetis	Madhuca oblongifolia	1.71	2.71	4.76	6,246	.07	21.44
31	Dangkalan	Calophyllum obliquinervium	5.84	5.28	14.10	8,136	0	16.20
32	Panau	Dipterocarpus gracilis	.27	2.93	4.46	6,552	6.34	16.86
33	Katmon	Dillenia philippinensis	.83	4.36	5.48	7,722	1.08	23.48
34	Batitinan	Lagerstroemia piriformis	.45	5.76	7.43	7,128	.68	28.82
35	Katong-lakihan	Amoora macrophylla	2.54	16.39	20.59	7,848	0	16.61
36	Narig	Vatica mangachapoi	.26	10.40	11.97	6,444	.05	15.76
37	Miau	Dysoxylum euphlebium	.53	6.66	7.40	7,740	7.72	18.22
38	Apitong	Dipterocarpus grandiflorus	.25	4.50	5.48	6,318	.64	13.37
39	Bok-bok	Xanthophyllum excelsum	.23	4.49	5.29	8,298	.03	23.35
40	Kamatog	Erythrophloeum densiflorum	.60	11.14	15.06	6,606	1.33	19.92
41	Dalingdingan	Hopea foxworthyi	2.30	9.74	14.64	8,064	.01	16.30
42	Katilma	Diospyros nitida	2.42	2.36	6.24	7,722	.14	17.03
43	Yakal	Shorea astylosa	.57	16.88	18.99	7,416	.12	27.77
44	Kamagong	Diospyros philippinensis	1.22	6.83	10.06	7,056	.26	23.53
45	Katong-matsin	Chisocheton pentandrus	--	--	--	--	--	--
46	Manaring	Lithocarpus soleriana	.13	5.85	7.21	8,208	.19	18.48
47	Ipil-ipil	Leucaena leucocephala	.25	14.12	14.77	7,776	2.40	10.90
48	Bolong-eta	Diospyros pilosanthera	1.57	3.19	6.14	7,920	.05	16.34
49	Makaasim	Syzygium nitidum	.25	5.98	6.39	8,316	.22	29.62
50	Alupag-amo	Litchi philippinensis	.48	8.08	8.84	7,794	.95	16.22

1/ Based on moisture-free weight.

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Table 3.--Wood-to-bark ratios of 18 Colombian and 22 Ghanaian hardwoods

No.	Common name	Botanical name	Specific gravity[1/]	Ratio	
				Wood	Bark
		COLOMBIAN SPECIES			
1	Peine mono	Apeiba apera	0.14	80	20
2	Ceiba	Ceiba pentandre	.22	73	27
3	Yarumo	Cecropia sp.	.25	91	9
4	Cirpo	Pourouma sp.	.37	90	10
5	Chingale	Jacaranda copaia	.37	85	15
6	Dormilon	Vochysia ferruginea	.45	88	12
7	Sande	Brosimum utile	.49	83	17
8	Sangretoro	Virola sebifera	.51	85	15
9	Arenillo	Catostemma alstonii	.54	71	29
10	Canelo	Nectandra sp.	.55	89	11
11	Perillo negro	Couma macrocarpa	.55	85	15
12	Casaco	Hieronyma sp.	.60	85	15
13	Carbonero	Enterolobium schomburgkii	.63	89	11
14	Chocho	Ormosia paraensis	.67	86	14
15	Carreto	Aspidosperma sp.	.69	82	18
16	Lecheperra	Helicostylis tomentosa	.79	85	15
17	Tamarindo	Dialium guianense	.82	93	7
18	Caimo	Pouteria sp.	.86	93	7
		GHANAIAN SPECIES			
1	Otu	Cleistopholis patens	.24	84	16
2	Effeu	Hannoa kleineana	.28	92	8
3	African corkwood	Musanga cecropioides	.30	97	3
4	Obeche	Triplochiton scleroxylon	.30	87	13
5	Antiaris	Antiaris africana	.31	88	12
6	Canarium	Canarium schweinfurthii	.34	89	11
7	Akoret	Discoglypremna caloneura	.37	91	9
8	African mahogany	Khaya ivorensis	.41	91	9
9	Dahoma	Piptadeniastrum africanum	.44	96	4
10	Gedu nohor	Entandrophragma angolense	.45	88	12
11	Niangon	Tarrietia utilis	.46	89	11
12	Scented guarea	Guarea cedrata	.48	93	7
13	Makore	Tieghemella heckelii	.50	88	12
14	Tallow tree	Allanblackia floribunda	.54	94	6
15	Lokonfi	Celtis adolphi-friderici	.55	96	4
16	Brown sterculia	Sterculia rhinopetala	.55	88	12
17	Eyong	Sterculia oblonga	.59	95	5
18	Adjouba	Dacryodes klaineana	.69	94	6
19	Afina	Strombosia glaucescens	.70	93	7
20	Kane	Anogeissus leiocarpus	.71	92	8
21	Kokoti	Anopyxis kleineana	.72	95	5
22	Ekki	Lophira alata	.81	95	5

1/ Dry weight, green volume basis.

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Table 4.--Ash and silica contents and heating values of Colombian and Ghanaian bark mixtures

Bark mixture[1/]	Colombian	Ghanaian
Ash.................pct	5.2	10.6
SiO_2................pct	1.2	2.2
Heat value.......Btu/lb	8,311	7,642

1/ Equal amounts (dry weight basis) of bark from each species listed in table 3.

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